Input from EPA on CBA Tools Used in EPA Analyses - Input to CBA Call #4 and MDG/FESG #2 Paper

A. Summary of CBA tools

Tool	Geographic Coverage	Impact Type	Effects/Metrics Modeled	Primary Impact Metrics	
				Physical	Monetary
APMT – Impacts	Global	Climate	CO_2, NO_x-CH_4, NO_x-O_3	Globally-averaged surface ΔT	Net Present Value of Mitigation Costs in US$
		Air Quality	$PM_{2.5}$	Premature mortalities	
		Noise	Area and Population Exposure, Housing Value, Rental loss	Population Impacted	
EUROCONTROL CBA	Europe	Climate	CO_2, H_2O,	Total CO_2 Equivalent	Average costs per pkm and tkm by mode
		Air Quality	NO_x,PM_{10},$PM_{2.5}$	Premature mortalities, Biodiversity and crop losses, Building & Material damages	
		Noise	Area and Population Exposure	Population Impacted	
Tools Used in EPA Analyses	Global and US	Climate (global)	CO_2, N_2O, CH_4	Total GHG emissions change	Social Cost of Carbon (SCC), Social Cost of Methane (SC-CH4), Social Cost of Nitrous Oxide (SC-N2O)
				Surface temperature change Sea level rise Ocean acidification (MAGICC)	n/a
		Air Quality (US)	Criteria and Air Toxic Pollutants	Predicted ambient pollutant concentrations (CMAQ); Mortality and morbidity health effects measured in terms of change in incidence (BenMAP)	Valuation of Avoided Health Effects
		Noise			
Aviation Integrated Modeling	Global	Climate	NO_x, CO_2, H_2O, SO_2	Radiative impact/emissions reduction	Marginal Abatement Costs (€/person/year)
		Air Quality	NO_x,PM_{10},$PM_{2.5}$	Emissions concentration	
		Noise	Contours/Population Exposure	Population Impacted	

DLR	Europe	Climate	CO_2, H_2O, SO_2	Rising sea levels/crop shortfalls	Net Damage Costs (in €)
		Air Quality	PM_{10},$PM_{2.5}$	Changes in mortality/morbidity	
		Noise	Area and Population Exposure	Changes in mortality/morbidity	

1.5 Environmental Protection Agency (EPA) Regulatory Impact Analysis (RIA)

1.5.1 **Overview**

- EPA develops Regulatory Impact Analyses (RIAs) to support the development of national mobile source regulations.

- EPA's mobile source Regulatory Impact Analyses (RIA) provide estimates of the projected changes in ambient concentration, the incremental costs, and the quantified/monetized human health benefits of attaining new mobile source standards for the control of criteria and toxic pollutants. As relevant, they also discuss climate change impacts and the incremental monetized benefits of reducing greenhouse gas emissions, such as carbon dioxide and methane.

- EPA fulfills the requirements of Executive Order 12866 and the guidelines of OMB Circular A-4, as well as its own guidelines for conducting economic analyses.[1]

1.5.2 Assumptions, Input Data and Modelling Approach

Module	Model Inputs	Source	Model Outputs	Modeling Approach	Assumptions
Air Quality (CMAQ)	1) Emissions for the base year and future year reference and control cases 2) Meteorology for the base year 3) Boundary concentrations for the base year from a global photochemical model	Air Quality Modeling Platform[2]	Hourly concentrations of ambient criteria and air toxic pollutants, at the 12km grid cell level, with 25 vertical layers up to 50 millibars, for the continental US, for the projected future year. Model predictions are used in a relative sense to estimate scenario-specific, future-year concentrations of PM2.5 and ozone. For example, we compare a 2040 reference scenario (a scenario without the mobile source standards) to a 2040 control scenario which includes the mobile source standards.	CMAQ is a non-proprietary computer model that simulates the formation and fate of photochemical oxidants, primary and secondary PM concentrations, acid deposition, and air toxics for given input sets of meteorological conditions and emissions. CMAQ includes numerous science modules that simulate the emission, production, decay, deposition and transport of organic and inorganic gas-phase and particle-phase pollutants in the atmosphere.	Meteorology and stationary source emissions remain constant in future years (i.e., consistent with the base year inputs)

Criteria Pollutant Benefits (BenMAP)	Ambient PM2.5 and Ozone Concentration Data	CMAQ	Incidences of • Premature mortality • Hospital admissions • Emergency Room visits etc. and their associated monetized unit values	• Changes in exposure to population is calculated • Selection of health endpoints to develop health impact functions • Valuation of avoided health impacts • Use of Monte Carlo method for estimating random sampling error associated with the concentration response functions and economic valuation functions	• All fine PM particles irrespective of size are equally potent • Health impact function for fine PM particles is linear
	Population Data	US Census			
Climate	Emissions Data	NEI	• Monetized estimates of the benefits of reducing GHG emissions.	EPA has applied the U.S. Government's estimates of the social cost of carbon (SC-CO_2) to the incremental CO_2 reductions. The USG developed the SC-CO_2 estimates using three integrated assessment models and recommended four SC-CO_2 values for use in regulatory analysis. See the OMB website for methodological details and the schedule of estimates.[3] EPA has also applied Marten et al. (2014) estimates of the social cost of methane (SC-CH_4) and social cost of nitrous oxide (SC-N_2O) to incremental reductions in methane and nitrous oxide, respectively.[4]	• The four SC-CO_2 estimates are: average at discount rates 2.5, 3, and 5%, respectively, and the 95th percentile SC-CO_2 at a 3% rate. • SC-CO_2 estimates are specific to the year of emissions and increase over time. • SC-CO_2 estimates are global measures. • The SC-CH_4 and SC-N_2O estimates are consistent with the modeling assumptions

					underlying the SC-CO_2 estimates.
			• Temperature, sea level rise, ocean acidification	GHG and other emissions are used as inputs to an energy-balance climate model such as MAGICC or Hector.[5]	• Climate sensitivities from 1.5 to 6 degrees can be calculated

1.5.3 **Case Study**: Phase 2 GHG Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles

Objective: To provide an example of the methodology for estimating and monetizing the health benefits expected from reducing emissions from mobile sources.

Method:

- The CMAQ air quality model estimates air quality concentrations at 12km grid cell resolution.

- The Environmental Benefits Mapping and Analysis Program (BenMAP) is used to estimate the health benefits associated with reductions in ambient pollutant concentrations due to implementing the standards.

  EPA applied the U.S. Government's estimates of the social cost of carbon to the incremental CO2 reductions to estimate the benefits of CO2 reductions. EPA also estimated the benefits of non-CO2 greenhouse gas reductions by applying Marten et al. (2014) estimates of the social cost of methane and social cost of nitrous oxide to incremental reductions in methane and nitrous oxide, respectively.[6]

Social Cost of CO2, 2012 – 2050a (in 2013$ per Metric Ton)

CALENDAR YEAR	DISCOUNT RATE AND STATISTIC			
	5% Average	3% Average	2.5% Average	3% 95th percentile
2012	$12	$36	$58	$100
2015	$12	$40	$62	$120
2020	$13	$46	$68	$140
2025	$15	$51	$75	$150
2030	$18	$55	$80	$170
2035	$20	$60	$86	$180
2040	$23	$66	$92	$200
2045	$25	$70	$98	$220
2050	$29	$76	$100	$230

Note:
[a] The SC-CO_2 values are dollar-year and emissions-year specific and have been rounded to two significant digits. Unrounded numbers from the current SC-CO_2 TSD were adjusted to 2013$ and used to calculate the CO_2 benefits.

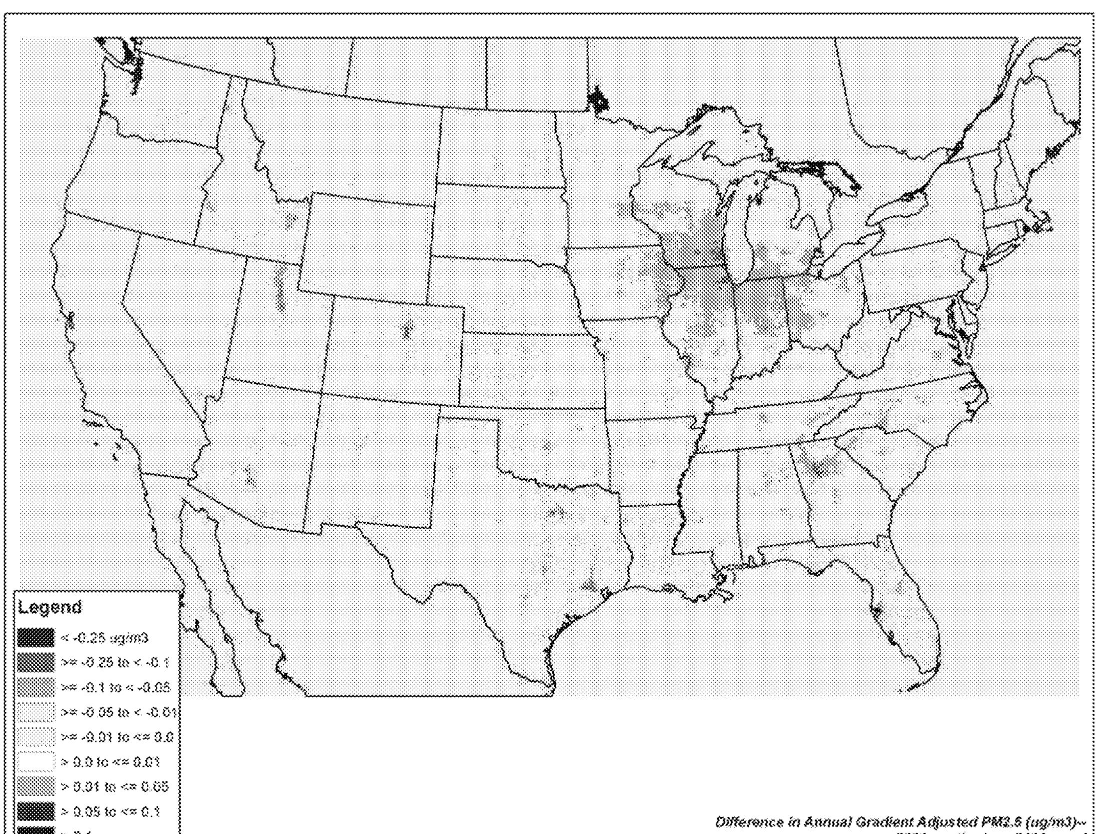
Social Cost of CH4 and Social Cost of N2O, 2012 – 2050a (in 2013$ per Metric Ton)

YEAR	SC-CH_4				SC-N_2O			
	5% Average	3% Average	2.5% Average	3% 95th percentile	5% Average	3% Average	2.5% Average	3% 95th percentile
2012	$440	$1,000	$1,400	$2,800	$4,000	$14,000	$21,000	$36,000
2015	490	1,100	1,500	3,100	4,400	14,000	22,000	38,000
2020	590	1,300	1,800	3,500	5,200	16,000	24,000	43,000
2025	710	1,500	2,000	4,100	6,000	19,000	26,000	48,000
2030	830	1,800	2,200	4,600	6,900	21,000	30,000	54,000
2035	990	2,000	2,500	5,400	8,100	23,000	32,000	60,000
2040	1,100	2,200	2,900	6,000	9,200	25,000	35,000	66,000
2045	1,300	2,500	3,100	6,700	10,000	27,000	37,000	73,000
2050	1,400	2,700	3,400	7,400	12,000	30,000	41,000	79,000

Note:
[a] The values are emissions-year specific and have been rounded to two significant digits, as shown in Marten et al. (2014). These rounded numbers were used to calculate the GHG benefits.
[b] The estimates in this table have been adjusted to reflect the minor technical corrections to the SC-CO2 estimates described above. See the Corrigendum to Marten et al. (2014), http://www.tandfonline.com/doi/abs/10.1080/14693062.2015.1070550

1.5.4 Sample Outputs

Projected Change in 2030 Annual PM2.5 Concentrations[7]



Estimated Monetary Value of Changes in Incidence of Health and Welfare Effects (millions of 2010$)[8]

HEALTH ENDPOINTS		2030 (5TH AND 95TH PERCENTILE)
$PM_{2.5}$-Related Health Effects		
Premature Mortality – Derived from Epidemiology Studies[b,c]	Adult, age 30+ - ACS study (Krewski et al., 2009)	
	3% discount rate	$6,100 ($910 - $14,000)
	7% discount rate	$5,500 ($820 - $13,000)
	Adult, age 25+ - Six-Cities study (Lepeule et al., 2012)	
	3% discount rate	$14,000 ($2,000 - $33,000)
	7% discount rate	$12,000 ($1,800 - $30,000)
	Infant Mortality, <1 year – (Woodruff et al. 1997)	$13 ($1.8 - $32)
Non-fatal acute myocardial infarctions		
Peters et al., 2001		
3% discount rate		$96 ($21 - $230)
7% discount rate		$93 ($19 - $220)
Pooled estimate of 4 studies		
3% discount rate		$10 ($2.6 - $27)
7% discount rate		$10 ($2.4 - $27)
Hospital admissions for respiratory causes[d]		$5.9 (-$1.6 - $11)
Hospital admissions for cardiovascular causes		$9.9 ($5.0 - $17)
Emergency room visits for asthma[d]		$0.15 (-$0.02 - $0.29)
Acute bronchitis (children, age 8–12)[d]		$0.49 (-$0.02 - $1.2)
Lower respiratory symptoms (children, 7–14)		$0.27 ($0.11 - $0.51)
Upper respiratory symptoms (asthma, 9–11)		$0.62 ($0.18 - $1.4)
Asthma exacerbations		$1.1 ($0.14 - $2.7)
Work loss days		$12 ($11 – $14)
Minor restricted-activity days (MRADs)		$34 ($20 - $49)
Ozone-Related Health Effects		
Premature Mortality, All ages – Derived from Multi-city analyses	Bell et al., 2004	$1,100 ($150 - $2,800)
	Huang et al., 2005	$1,600 ($220 - $4,100)
	Schwartz, 2005	$1,700

		($220 - $4,400)
Premature Mortality, All ages – Derived from Meta-analyses	Bell et al., 2005	$3,600 ($510 - $8,800)
	Ito et al., 2005	$5,000 ($740 - $12,000
	Levy et al., 2005	$5,100 ($760 - $12,000)
Hospital admissions- respiratory causes (adult, 65 and older)		$21 ($2.5 - $39)
Hospital admissions- respiratory causes (children, under 2)		$3.7 ($1.9 - $5.4)
Emergency room visit for asthma (all ages)		$0.14 (-$0.003 - $0.41)
Minor restricted activity days (adults, age 18-65)		$43 ($19 - $73)
School absence days		$21 ($9.3 - $31)

[a] Monetary benefits are rounded to two significant digits for ease of presentation and computation. PM and ozone benefits are nationwide.
[b] Monetary benefits adjusted to account for growth in real GDP per capita between 1990 and the analysis year (2030).
[c] Valuation assumes discounting over the SAB recommended 20 year segmented lag structure. Results reflect the use of 3 percent and 7 percent discount rates consistent with EPA and OMB guidelines for preparing economic analyses.
[d] The negative estimate at the 5th percentile confidence estimate for this morbidity endpoint reflects the statistical power of the study used to calculate this health impact. This result does not suggest that reducing air pollution results in additional health impacts.

Impact of GHG Emissions Reductions on Projected Changes in Global Climate Associated with the Final Program (Based on a Range of Climate Sensitivities from 1.5-6°C)

VARIABLE	UNITS	YEAR	PROJECTED CHANGE
Atmospheric CO_2 Concentration	ppmv	2100	-1.2 to -1.3
Global Mean Surface Temperature	°C	2100	-0.0027 to -0.0065
Sea Level Rise	cm	2100	-0.026 to -0.058
Ocean pH	pH units	2100	+0.0006[a]

Note:
[a] The value for projected change in ocean pH is based on a climate sensitivity of 3.0.

8.REFERENCES

[1] https://www.whitehouse.gov/sites/default/files/omb/inforeg/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf
[2] https://www.epa.gov/air-emissions-modeling/2011-version-6-air-emissions-modeling-platforms
[3] See U.S. Office of Management and Budget website for detailed information about the social cost of carbon (SC-CO2) estimates, https://www.whitehouse.gov/omb/oira/social-cost-of-carbon. See the Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis (July 2015) at this site for the schedule of estimates, https://www3.epa.gov/climatechange/EPAactivities/economics/scc.html.

[4] See the 2016 final rulemaking to update the new source and performance standards for the oil and gas industry, https://www3.epa.gov/airquality/oilandgas/may2016/nsps-ria.pdf, and the Phase 2 Medium- and Heavy-Duty Greenhouse Gas Standards proposed rulemaking, https://www3.epa.gov/otaq/climate/documents/420d15900.pdf, for examples of recent applications.

[5] See the Phase 2 Medium- and Heavy-Duty Greenhouse Gas Standards proposed rulemaking for example of a recent analysis in a rulemaking: https://www3.epa.gov/otaq/climate/documents/420d15900.pdf.

[6] See the Phase 2 Medium- and Heavy-Duty Greenhouse Gas Standards proposed rulemaking: https://www3.epa.gov/otaq/climate/documents/420d15900.pdf.

[7] See the Tier 3 Vehicle Emission and Fuel Standards final Rulemaking: https://www3.epa.gov/otaq/documents/tier3/420r14005.pdf

[8] See the Tier 3 Vehicle Emission and Fuel Standards final Rulemaking: https://www3.epa.gov/otaq/documents/tier3/420r14005.pdf